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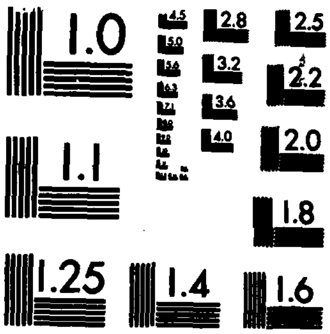

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RESEARCH AND DEVELOPMENT
PROJECT SELECTION METHODS
AT THE AIR FORCE
WRIGHT AERONAUTICAL LABORATORIES

THESIS

Jeremy R. Prince, B.S.
Captain, USAF

AFIT/GSM/LSY/85S-29

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RESEARCH AND DEVELOPMENT PROJECT SELECTION METHODS
AT THE AIR FORCE WRIGHT AERONAUTICAL LABORATORIES

THESIS

Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology
Air University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Systems Management

Jerry R. Prince, B.S.
Captain, USAF

September 1985

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Table of Contents

List of Tables

Abstract

This investigation sought to determine how in-house research projects are selected at the U.S. Air Force Wright Aeronautical Laboratories (AFWAL). The problem was explored by studying ten aspects of the research project selection process.

This analysis was accomplished by using a combination of personal and telephone interviews. Ten individuals from each of the four AFWAL Laboratories were interrviewed. The results illustrated that few of the respondents used a formal decision method model when selecting research projects. Most of the in-house projects selected at AFWAL are chosen via a consensus of agreement between the various levels of management in each laboratory.

RESEARCH AND DEVELOPMENT PROJECT SELECTION METHODS

AT THE AIR FORCE WRIGHT AERONAUTICAL LABORATORIES

I. Introduction

Background

With the emphasis the Reagan administration has placed on military spending, funding for research and development (R&D) in both the Air Force and the private sector is expected to increase. R&D funding is already a significant part of the budget for both the Air Force and many corporations in the private sector. Therefore, R&D project management efficiency must be maximized to insure that these funds are managed effectively.

The nature of R&D in private industry is similar in many ways to R&D conducted in a military environment. A study of the problems in both arenas could yield insight into ways of increasing R&D management efficiency in Air Force laboratories.

A crucial and difficult decision for laboratory managers is the proper selection of research projects for their laboratory project portfolios. While there have been many studies conducted examining this process in corporate laboratories, few studies of this nature have been conducted in Air Force laboratories.

General Issue

How can the selection of research projects for Air Force laboratory project portfolios be improved? Research project portfolio selection is crucial to Air Force laboratory managers for three reasons. First, their decisions will influence technology development that may be incorporated into new weapons systems. Second, these managers seek to optimize limited resources in competition with numerous projects. Third, the selection of research projects is an important function of laboratory management. To accomplish this task a manager must trade off and prioritize candidate projects so they match available resources and organizational objectives.

Specific Problem

How do Air Force Laboratory managers presently select research projects for their laboratory project portfolios? Research project proposals come to laboratory managers from a variety of sources. On one end of the spectrum are external source research projects that come attached with an appropriation from upper levels of the Air Force or DOD. At the opposite end are those research proposals originated by laboratory researchers that require laboratory funds. This research effort focuses on research projects that laboratory managers have the discretion of selecting or rejecting.

Research Objectives

Ten aspects of the research project selection process at the Air Force Wright Aeronautical Laboratories (AFWAL) were explored.

This section delineates those research objectives and describes the rationale for exploring them.

1. Research Project Selection Factors. Before selecting a project a manager must consider the attributes of a project and compare them to research goals. These attributes will be the inputs into any decision-making process the manager uses. Therefore, the first research objective was to gather data concerning project selection factors used in AFWAL.

2. Formal Decision Method Use. The second objective was to determine the extent that AFWAL researchers and managers use formal decision-making methods in selecting research projects. Patterns of the use of such methods in the various laboratory organizations were explored.

3. Formal Decision-Making Techniques. The third research objective focused on decision-making techniques now being used at AFWAL. Inputs for this question were generated from information gathered during a literature review of this subject.

The effects of a management science/operations research background were also evaluated since operations research plays a prominent role in decision-making theory and practice. A manager who is familiar with this discipline may be inclined to apply some of it to the research project selection process.

4. Decision-Making Technique Awareness. The fourth objective was to determine what, if any, decision-making methods the participants of this study were cognizant of but did not use. The objective was to

gather insights into the viability or impracticality of the various decision techniques.

5. Respondent's Desires to Change Methods. The fifth objective sought to determine the degree to which the respondents were satisfied or dissatisfied with their present way of selecting research projects. If the respondents were dissatisfied, their recommended solutions for improving the process were sought.

6. Formal Laboratory Management Training. The sixth objective was to identify any relationship that may exist between the knowledge gained from specific laboratory management training courses and their applications to research project selection.

7. Manager's Budget vs Formal Decision Methods. The seventh research objective focused on how the size of a manager's budget would impact his inclination to use a formal decision method. The assumption entering this research was that the larger the budget a manager controls, the higher the probability that manager will use some formal decision method.

8. Project Selection/Assignment vs Formal Decision Method Use. The eighth objective was to see if the selection and/or assignment volume of an individual influences that person's propensity to use a formal decision method. The underlying hypothesis here was that a heavier volume of project selections and/or assignments would by necessity make using such a method more attractive.

9. Selection Method Propensity vs Project Value. The ninth research objective was to determine if a project's dollar value directly influences the formal decision method used. The initial

hypothesis was that the higher the dollar value of a project, the more likely that project should be selected using a formal decision-making method.

10. Project Portfolio Selection. The final research objective focused on whether different techniques were used for single projects versus portfolio projects. Many commercial laboratories treat the function of selecting research project portfolios (several projects to meet a single research objective) differently than selecting a single research project. The purpose of researching this area was to determine if AFWAL also conducted this selection process differently.

II. Literature Review

Introduction

This literature review covers the following areas: previous survey studies in R&D project selection, a survey of some specific R&D project selection model research, and a review of some common selection methods that are used in selecting R&D projects.

Previous Survey Studies in R&D Project Selection

Baker and Pound, 1964. This survey was conducted to confirm two observations that the two researchers had concerning R&D project selection methods. The first observation was that, despite the fact that many researchers had published papers on R&D project selection, few had published more than one or two papers. The second observation was that very few of the decision methods proposed in these papers were used (4:124).

Baker and Pound used an extensive literature review and a combination of interviews and written survey techniques with a sampling of laboratory managers from a variety of laboratories. Many of the managers were present at a particular seminar. The models examined during the course of the literature review were used as inputs for the surveys and interviews (4:124).

Based on the responses received from the interviews and surveys, Baker and Pound made the following conclusions: 1) there has been insufficient testing of many of the R&D selection models, 2) objectives and criteria of R&D projects are insufficiently clear to make good use of many of the models, and 3) the models did not adequately deal with the variable of technical uncertainty (4:130-131).

Cetron, Martino and Roepcke, 1967. The researchers performed a literature review, which presented approximately thirty methods that were used for quantitative evaluation and selection of R&D projects. Each method was "compared and contrasted with each other relative to a standard set of features which they may possess, to a standard set of characteristics relating to ease of use, and to scientific or technological areas of applicability" (7:4).

The features of the methods that were analyzed were:

1. Utility Measure - utility or success value of the R&D project.
2. Probability of success
3. Orthogonality of Criteria - the fact that certain criteria may be mutually exclusive.
4. Sensitivity
5. Rejected Alternatives Retention - retaining a project that has previously been rejected due to a funding limitation.
6. Classification Structure - relationship between R&D project and hierarchy of organizational goals.
7. Time
8. Strategies
9. System Cross Support
10. Technology Cross Support
11. Graphical Display

12. Flagging - pointing up problem areas

13. Optimization Criteria

14. Constraints

15. Degree of Computerization Required

The scientific and technological areas of applicability that were examined were:

1. Research

2. Exploratory Development

3. Advanced Development

4. Engineering

The researchers drew the following conclusions:

> Each method, within its capabilities and limitations, can provide assistance to the management of an R&D enterprise in appraising the worth of its R&D effort. In particular, the use of quantitative methods tends to eliminate bias, provide a degree of consistency, and force managers to render their judgements more explicit in evaluating R&D programs. [7:10]

The methods were, however, limited by two factors -- the validity of the information inputs by laboratory personnel and higher management support use of the system (7:10).

<u>Baker and Freeland, 1975</u>. The authors presented an assessment of the current literature that dealt with "quantitative models of the R and D project selection and resource allocation decision." The models reviewed were divided into two categories -- benefit measurement and resource allocation (3:1164).

Two main findings resulted from this research. The first finding was the contention that more empirical research was needed in understanding the R&D environment as well as the "behavior process by which decision and information systems become adopted and implemented" (3:1172).

The second finding was that decision models were giving way to decision information systems. Two reasons were given for this phenomena. First, decision models do not encompass all the relevant factors which are used in R&D decisions, forcing managers to consistently readjust their resource allocations. Second, most criteria are not easily quantified, thereby requiring they be handled by more qualitative methods (3:1173).

A Selected Survey of R&D Project Selection Model Research

Asher, 1962. A linear programming model was developed for the purpose of allocating a scarce resource in the pharmaceutical industry. This resource was professional manpower, and it had to be allocated among many alternative research projects (2:154).

Other constraints considered were: economic value, probability of success, manhours required to test or screen a project, manhour availability, cost per manhour and raw material availability. All these constraints were integrated in the formulation of a linear programming model (2:154).

The solution obtained indicated "the optimum allocation of professional manpower over the most attractive projects to maximize the return to the corporation" (2:154).

Watters, 1967. The author examined the problem of R&D project portfolio selection in organizations. He took the perspective of "investing" projects in an economic sense and sought to construct a method that balanced both profitability and investment risk (19:2-3).

The method combined aspects of utility theory, probability theory, and mathematical programming. This model is a systematic technique that can be used in considering factors which other models do not address (19:135).

> Specifically, a method was developed for solving R&D project selection problems in which (1) cash flows are not known with certainty, (2) some or all of the investment opportunities are interrelated, (3) limited funds in multiple fiscal periods necessitates the imposition of multiperiod probabilistic budget constraints, and (4) the suitability of undertaking a given portfolio of investment opportunities depends upon both profitability and wish considerations. [19:135]

Moore and Baker, 1969. The authors performed a computational analysis of scoring models and their application to R&D project selection. They stated that the major weakness of these types of models is their arbitrary construction and the inability of model builders to deal with the impact of certain structural considerations on project scores (15:B-212).

Two principal research questions were investigated:

> 1. Is it possible to construct a scoring model such that its performance is consistent with other models having economic and constrained optimization structures?
>
> 2. If such consistency can be achieved, what properties of the scoring model's structure are responsible for the consistency? [15:B-214]

The methodology used involved an analytical approach as opposed to a theoretical approach. A tactical simulator was generated that compared the behavior of a scoring model against two other models that represented economic and constrained optimization classes (15:B-212).

Moore and Baker made some observations about scoring models. Scoring models were stronger tools than they had originally thought. Its strengths lay in the ability of the method to process economic, historical and other environmental types of data. However, further studies of projects operating in a real R&D setting were needed to adequately evaluate performance (15:B-230-231).

The authors state that their research supports the conjecture that scoring models may be used throughout the life of an R&D project or they can be used for various evaluations. They caution that additional testing with actual data must be done before either approach is adopted (15:B-231).

Gear, Lockett and Pearson, 1971. The researchers concerned themselves with an analysis of a selection of R&D portfolio selection models. The research methods used were a literature review to gather inputs (models) and an analysis of such models to determine strengths and weaknesses (10:66).

> The models are classified according to whether they are based on linear, integer, chance constrained or dynamic programming. . . . The evaluation is in terms of data requirements; built-in assumptions; ease of computation; usefulness of output; versatility of application. [10:66]

The authors confirm, after brief evaluations of each model, that it is quite difficult to pick an appropriate model. Further testing using real R&D field data is required for just about all of the models that the authors evaluated (10:75).

Souder, 1975. The author used an organizational behavior technique, called an impact method, to attempt an organizational consensus in specifying R&D project selection criteria. The experiment encompassed four different organizations, known only as companies A and B with divisions X and Y (18:669).

> The method consists of the repeated use of a paired comparison instrument, with group discussions and member interactions. . . . It was concluded that the impact method may be generally useful for disclosing hidden value conflicts. However, the achievement of high levels of shared values and decision consensus may be inhibited where either a strong central leader is lacking or where individuals are unclear about the nature of the larger goals of the organization. [18:669]

Souder believes that this procedure is useful in planning and policy formulations in addition to R&D planning. However, consensus varies on the willingness of participants to allow open conflict. When open conflict is repressed, cliques of dissatisfaction often arise, seriously impinging the consensus process (18:680).

Aaker and Tyebee, 1978. The authors constructed a model that dealt with the selection of interdependent R&D projects. The model covers three areas of interdependence: resource utilization, technical overlap, and interaction with respect to value contribution. The model is also structured to assist people with diverse backgrounds in an organization to convey their inputs into the R&E planning process (1:30).

> Typically, the R&D group would best be able to estimate the project costs, including resources overlap, generate the various probability inputs required, and identify technically dependent projects. The profit implications of profit outcomes would require sales forecasts by several marketing groups and cost estimates by production managers. Finally, global budget constraints, internal rate-of-return constraints, and the identification of the long range strategic value of financial managers and top management. The model can thus be viewed as a vehicle by which these varied organizational groups will communicate and interact during the R&D funding decision-making process. [1:36]

<u>Brooks, 1979</u>. The author formulated a descriptive method called "policy capturing" in an attempt to model the decision making process that Air Force laboratory managers used when making R&D project selection decisions. A survey of laboratory managers was conducted and the respondents were categorized according to management level, division, and type of laboratory project. Models were constructed to determine the extent, if any, that a consensus on R&D project selection existed among them (6:viii).

The survey instrument incorporated six predictive factors that Air Force laboratory personnel seemed to use the most. This determination was the result of previous work by Air Force Institute of Technology (AFIT) faculty. The six factors were: 1) cost-benefit ratio, 2) technical merit, 3) resource availability, 4) likelihood of success, 5) time period, and 6) Air Force need (6:51-52).

Captain Brooks concluded that his study supported policy capturing as a technique. His major observation was that a consensus in R&D decision making did not exist between different divisions, nor was their much consensus in this area within divisions. In addition, managers often did not use a decision making process in the same manner as they had originally perceived that method (6:89).

Captain Brooks' work is particularly notable in that it is one of the few attempts to construct a descriptive, as opposed to a prescriptive, model.

Chiu and Gear, 1979. The authors present an application of stochastic integer programming, formulated to a portfolio of projects. Each of the projects was planned with the aid of a decision tree structure. Subsequent studies were conducted after a year's duration to assess performance of the model in practice (8:2).

Chiu and Gear concluded that the decision tree structure of the model adequately projected the paths that the research projects actually took. As a minimum, the model provided a convenient starting point for interactive mode operation. On the negative side, the model did not adequately deal with the interdependencies of the projects (8:5-6).

Golabi, Kirkwood, and Sicherman, 1981. The authors described a procedure for selecting a portfolio of R&D solar energy projects. The method made use of multiattribute preference theory and was used by the U.S. Department of Energy (11:174).

> The technical quality of each proposed applications experiment was summarized through the use of multiple evaluation measures, or attributes. These were combined into a single index of the overall technical quality of an experiment through the use of a multiattribute utility function. Recently derived results in measurable value theory were applied to derive an index of the overall technical quality of a portfolio of experiments. Budgeting and programmatic issues were handled through the use of constraints. This approach allowed the portfolio selection problem to be formulated as an integer linear program. [11:174]

The authors report that the procedure decreased dramatically the time it took to evaluate R&D project proposals. However, implementation requires proper management techniques and a heavy degree of computer support (11:188).

A Review of Some Commonly Recurring Selection Models

The literature in this area is rich in documenting the applications and innovations that have evolved in the field over the past quarter century. The selection methods here differ from the previously described models in that they can be used either independently or as components or subelements of models. Some of the more common techniques will be discussed here. They include: 1) checklist and profile charts, 2) scoring models, 3) cost/benefit ratios, 4) decision trees, 5) linear programming, 6) goal programming, 7) dynamic programming, 8) chance constrained programming, and 9) multiple objective techniques.

Checklist and Profile Charts. This method is regarded by many in the field as the simplest of the techniques. Its use involves completing a checklist for the project under consideration (13:16). The method works in the following manner:

> Criteria are listed which are believed to be important factors in determining the eventual success or failure of the R&D effort and the ultimate product. Each candidate project is then subjectively rated on the basis of each criteria listed. The opinions of several individuals could be summarized in checklist by averaging their opinions. [18:16]

Some of the advantages of checklists are: 1) they are simple and easy to use, 2) criteria are easily matched with available information, 3 they accommodate information that does not fit well into other more structured models (noneconomic factors, social impacts, environmental concerns), and 4) they identify project weaknesses quickly via a criteria rating system (13:16).

Among the disadvantages often cited are: 1) complex problems are overlooked, 2) complex interrelationships with other projects are overlooked, 3)individual factors are not prioritized, and 4) results could be affected by inaccurate information from respondents (13:16).

Scoring Models. Scoring techniques are the next level of sophistication up from checklist and profile charts. "Scoring models compute an overall project score based on ratings assigned to each project for each relevant decision criteria and are designed to operate with the subjective input data which exists as the research stages of the project life" (15:213).

Byron Jackson relates some of the advantages and disadvantages of this technique:

> Scoring models retain the advantages of checklist and profile charts in terms of their ability to consider a wide range of economic as well as non-economic criteria. In addition, scoring models make it possible to provide a single number evaluation for each project and they areeasily modified to meet conditions (Dean & Nishry, 1964). The cost of this improvement is a significant increase in information requirements. The principle shortcomings of the approach are that the project is dimensionless, which limits its use to rank order comparisons; and the model development is nonformal, which makes it difficult in some situations to justify its use as opposed to economic or optimization models. [13:18]

Cost/Benefit Ratios. This technique attempts to balance project risks and project costs to aid the R&D decision maker.

> The techniques associated with cost-benefit analysis allow a decision maker to choose between alternative research projects by systematically evaluating the benefits and costs associated with each project into monetary equivalents. The project that provides the greatest net monetary benefit to the organization is then selected for further funding and development. Since the time period during which substantial costs are involved frequently varies from project to project, as does the time period during which benefits are expected to be received, the time value of money is a critical factor in the cost-benefit approach to evaluating research projects. The relative risk associated with each project must also be considered in determining which of a number of projects merits the resource investment required for development. [5:39]

The major benefit of using a cost/benefit ratio is that it forces decision makers to quantify their evaluations of a project. This quantification process forces decision makers to evaluate their projects with a clearer perspective. In addition, the method provides a single index to which other projects may be compared, thus simplifying the decision process (13:18).

The major disadvantage of using this method is that not all non-economic factors can be translated into dollar values. An example of this is the failure of the technique to handle resource constraints. Also, results are generally sensitive to the escalator factor used in net present value (NPV) calculations.

Decision Trees. Decision trees are a useful technique for graphically displaying possible outcomes and their probabilities of occurrence (14:810). Decision trees address a major problem of project selection; the interrelated nature of many research projects (13:18-19).

Decision trees have two strong points. First, "they focus attention on the individual subproject which make up a complete R&D project." Second, they "provide a more accurate description of the R&D decision process and offer a better basis for making decisions than other methods" (13:20).

This technique has two fundamental shortcomings. It requires a great deal of information, some of which is not always available, and it does not adequately deal with resource constraints (13:20).

Linear Programming. A linear programming model incorporates linear model solution techniques. "A linear model is one in which all of the functional relationships between the variables in the models are expressed in linear terms" (14:13).

Linear programming is used by commercial managers as "the most fundamental quantitative tool of R&D projects while recognizing limits on the available resources to carry out the projects" (12:21).

Linear programming formulation generally consists of three parts. First, the model requires an objective function which the user attempts to maximize or minimize. Second, the model contains a set of linear constraints, which represent resource constraints of one sort or another. Finally, nonnegativity restrictions are defined for resources that cannot be negative (14:73-74).

Some of the reservations R&D managers have expressed about linear programming are: 1) it has large information requirements, 2) it does not handle uncertainties in the R&D environment very well, 3) it fails to handle project interdependencies, and 4) fractions of projects carry over into the solution, distorting the output (12:22).

<u>Goal Programming</u>. Goal programming is a relatively new technique. In many respects, it is a modification of linear programming that deals with multiple objective goals. Markland describes the technique as follows:

> Goal programming . . . allows the decision maker the opportunity to include in the problem formulation multiple goals or objectives. Goal programming greatly enhances the flexibility of linear programming as it allows the inclusion of conflicting objectives while still yielding a solution that is optimal with respect to the decision maker's specification of goal priorities. The use of goal programming thus reflects a philosophy of trying to obtain an optimal compromise solution to a set of conflicting objectives. Goal programming has been applied to numerous multiobjective modeling situations, including linear or nonlinear functions and constraints, and both continuous and discrete variables. [14:254]

Nussbaum describes the formulation of a goal programming problem (17:30):

1. Isolate the decision variable.
2. Determine the goals/objectives of the decision maker.
3. Place the goals into priority levels.
4. Link decision variables and goals in a way similar to that found in a linear programming setup.

The effectiveness of goal programming lies in its ability to minimize deviations from the goals (17:30). Herein also lies its biggest defect. The results it yields are dependent upon the way those goals are articulated. It also has the same interrelatedness problem of linear programming.

Dynamic Programming. Dynamic programming incorporates dynamic models. A dynamic model deals with multiple time periods in selecting the optimal project alternative. A series of interrelated decisions are made that cover several time periods (14:13).

> Dynamic programming is really a general type of problem solving procedure that can be applied to sequential decision-making situations. The dynamic programming model, or set of equations, that is formulated must be developed uniquely for each problem solving situation. [14:556]

The chief benefit of dynamic programming is the way it handles the probability of technical success. This is due to the ability of this technique to formulate a nonlinear relationship between its inputs and the expected values of its projects.

This method is also effective in resource allocation. "If resource expenditures undergo a declining rate of contribution as more are expended in any one period, the resources are reallocated to other periods so as to maximize their overall contribution to project success (12:24).

Two problems are identified with this method. To use dynamic programming it is necessary to determine probabilities of technical success as a function of past and current research spending. This is often a complex task in and of itself. Also, only one resource constraint can be considered at any one time (12:24).

Chance Constrained Programming. This method treats resources as random variables rather than as constant parameters. It is used primarily for assessing R&D project portfolios as a group, after one of the member projects of that portfolio has experienced a significant breakthrough where that project may require a sudden surge of additional resources (12:24).

> The second constraint limits research activities at individual institutions. This constraint is a chance constraint which says that the probability that the institution has sufficient resources to carry out the research activities it has undertaken is at least equal to minimum values. [12:24]

This model has a number of disadvantages. Foremost among them is that this technique does not lend itself to easy mathematical resolution. In addition, models of this nature have extensive data requirements (12:24).

Multiple Objectives. this technique involves the use of objective functions which incorporate multiple objectives. This method can be used under conditions of either certainty or uncertainty. Many applications of multiattribute theory have found their way into this method (12:25).

> The contribution of multiattribute decision theory is twofold. The theory recognizes the problems of project selection where different scales are appropriate for measuring the multiple objectives of the decision maker, and the decision maker is not indifferent to the uncertainty surrounding the outcome of the R&D project. [12:26]

There are some serious drawbacks to this method. First, decision makers must provide great amounts of data. Second, the method is very much dependent on the decision maker being familiar with all attribute of his project. This is not always the case. Finally, this method often requires the use of nonlinear programming techniques, many of which are quite difficult to solve (12:26).

III. Methodology

This chapter reviews the methodology that was used to collect and analyze the data for this effort. The first section of the chapter covers the scope of the study includes the laboratories that participated in the study, the sample size of each laboratory, and the data gathering method used. The second section details the questions used in the study and the rationale behind their use. The third section describes the data analysis techniques used. The final section deals with the limitations of this research effort.

Scope

The data collection method used in this study consisted of a combination of personal and telephone interviews. The interviews consisted of twenty-two questions. A copy of the interview questions is provided in Appendix A.

The primary reason for the selection of the interview method was the exploratory nature of the research. No previous data bases existed that could have provided a suitable structure around which to build an adequate questionnaire. Another reason for the use of the interview method was that it provided for the flexibility of responses from laboratory managers being questioned. They could verbally add impromptu comments which they normally would not have written down.

The four laboratories chosen for this research were those that constitute the Air Force Wright Aeronautical Laboratories (AFWAL). They are: the USAF Avionics Laboratory, the USAF Aero-Propulsion Laboratory, the USAF Flight Dynamics Laboratory, and the USAF Materials Laboratory. All four elements of the AFWAL are located at Wright-Patterson AFB, Ohio. The four laboratories of AFWAL were chosen for this research due to the volume of in-house research projects that are conducted there and also because of their close geographical proximity to AFIT.

A sample of ten people from each laboratory was interviewed for a total of forty interviews. The individual interviews were selected in the following manner. First, a senior laboratory official in each laboratory was contacted to determine which managers would be most suitable for interviewing. This senior official was associated with a laboratory's long range planning (XR) office. Each of the managers recommended from this initial meeting was contacted and an interview request was made. If the manager responded positively an interview was conducted. Each of these managers in turn recommended additional managers who would consent to be interviewed.

The sole criteria of participation was that the individual be involved in selection of an in-house research project. However, it was not required that the participant be the sole selector of the research project.

The interviews used a combination of face-to-face and telephone methods. While the former was the most desired method, because of its flexibility, time limitations made use of the telephone method a necessity. Limitations of these methods will be discussed later in this chapter.

The Interview Format

The interview format was designed to answer the ten research objectives that were stated in Chapter I. This section explains the rationale behind the interview questions found in Appendix A.

Questions 1 through 4 provided demographic data in the form of the laboratory where the individual worked, whether he/she was in the military or in the civil service, his/her rank or grade and years experience working in a laboratory environment.

Question 5 determined the respondent's highest level of education.

Question 6 determined the respondent's management level in the laboratory organization.

Question 7 sought the participant's major field of study.

Question 8 sought an individual's operations research background to be used to answer the third research objective.

Questions 9 and 10 were the inputs to answer the sixth research objective, which was to determine a respondent's formal laboratory management training.

Question 11 was combined with question 15 to answer the seventh research objective -- how the size of a manager's budget would impact his inclination to use a formal decision-making method.

Questions 12 and 13 were combined with question 15 to answer the eighth research objective -- how the selection and/or assignment volume of an individual influences that person's prepensity to use a formal decision method.

Question 14 was the input to answer the first research objective, which involved gathering data concerning project selection factors used in AFWAL.

Question 15 was the input to answer the second research objective, which was to ascertain the extent AFWAL researchers and managers used formal decision methods in selecting research projects.

Question 16 was the input to answer the third research objective, which focused on decision-making techniques now being used at AFWAL.

Question 17 was combined with question 20 to answer the ninth research objective, which sought to determine if a project's dollar value directly influenced the formal decision method used.

Question 18 was the input to answer the fourth research objective, which focused on decision methods respondents were aware of but did not use.

Question 19 was the input to answer the fifth research objective, which was an attempt to gauge a participant's desire to change project selection methods.

Question 21 was the input to answer the tenth research objective, which dealt with project portfolio selection.

Analysis

The data collected from the interviews was recorded and analyzed. The analysis techniques used were frequency response and crosstab correlation of two or more variables. These techniques were utilized via the Statistical Package for the Social Sciences (SPSS), a computer based statistics package (16). Upon completion of the data analysis, conclusions were drawn and recommendations were made.

Limitations

The personal interview method has two problems associated with it -- bias and cost (9:299). Cost was not a problem in this research, but the problem of bias had to be addressed. Emory defines three components of bias: sampling error, nonresponse error, and response error (9:299).

Sampling Error. The sampling error is measured in terms of its validity. Validity has two components -- accuracy and precision. Accuracy is "the degree to which bias is absent from the sample." Precision is defined as "precision of estimate" (9:148).

The nature of the research for this project was of an exploratory nature. No known studies of research of this type concerning the Air Force laboratories in general and AFWAL in particular were available. Sampling was based on interviews with laboratory managers who were involved in the in-house research project selection process. This type of sampling is justified on the basis of the following argument by Emory:

> [Such samples] are appropriate at the earliest stages of a research design, when one is first attempting to develop hypotheses and procedures for measuring them. Then, along with reading the literature and discussing ideas with colleagues, friends and relatives, exploratory date gathering is worthwhile. Any sort of sample may be useful when very little is known. Just a few interviews can pinpoint major problems with questions and dimensions of the project that the research may have ignored. [9:179]

Nonresponse Error. This error type results when respondents do not wish to be interviewed or when respondents cannot be found (9:299). None of the respondents refused to be interviewed when contacted. Establishing initial contact with prospective respondents was the chief problem in this area.

Respondent Error. This error bias is the difference between reported and actual data (9:301). There are a number of sources for this error type: 1) errors in processing or tabulating data, 2) failure of a respondent to provide complete and accurate information, and 3) bias caused by the researcher (9:301-302).

Error bias in processing and tabulating data was ameliorated by the use of manual and computer generated statistical methods. A preplanned questionnaire was used for all the interviews to limit interviewer bias. Respondent bias, however, is difficult to verify so respondent accuracy will be assumed.

IV. Data Analysis

Introduction

This chapter reflects an analysis of the data obtained from the forty interviews. The data is summarized and presented by the following topical areas: 1) demographic data, 2) research project selection factors, 3) the extent of formal decision-making method use by laboratory managers, 4) decision-making techniques used by the participants, 5) decision-making techniques the respondents were aware of, 6) the extent that the sampled individuals desired to change their selection methods, 7) participant's formal laboratory training, 8) manager's budget size vs formal decision method use, 9) project selection/assignment vs formal decision method use, 10) selection method propensity vs project value, and 11) project portfolio selections.

Demographic Data

Each of the four laboratories (Avionics, Aero Propulsion, Flight Dynamics and Materials) of AFWAL participated in the study, with a sampling of ten participants from each lab for a total of forty interviews. Of these forty participants, four were active duty military and thirty-six were civilian government employees.

The ranks and grades of the participants were heavily skewered towards the upper levels (Table B.1). The breakout of the military respondents was: one lieutenant colonel, one major and two first lieutenants. Of the civil service employees interviewed, nearly three-fourths (71%) were in the senior grades of GS-13 through GS/GM-15. Correspondingly, nearly two-thirds (65%) had ten or more years experience in laboratory work (Table B.2).

The research sample was also a very highly educated group (Table B.3). All but one of the respondents had at least a baccalaureate degree. Over two-thirds (67.5%) had a master's and/or Ph.d degree. The major field of study (Table B.5) was engineering (65%). Science was the next most selected field (32.5%). One participant was a math major and no one had a non-technical degree.

While the pay grades of the participants were weighted heavily towards the upper grades, the management levels were weighted in the opposite direction (Table B.4). Most of the participants were at the researcher level (40%), with those occupying supervisory positions at the next management level coming close behind (37.5%). Eight branch chiefs and one directorate head rounded out the sample.

Research Project Selection Factors

The overall rating for the order of importance of the factors listed was determined by the number of participants who indicated a particular factor's level of importance by rating it on a scale from one (most important) to nine (least important). A given scale level could have multiple factors (i.e., a respondent could determine that there should be two number one factors).

The overall sample ranking of factors from most important to least important are as follows (Table B.13):

1. Air Force Need
2. Technical Merit
3. Resource Availability
4. Likelihood of Success
5. Timeliness of Completion
6. Keep Contractor Honest
7. Educating Personnel
8. Cost/Benefit Ratio
9. Other (unlisted) Factors

The ranking of factors by laboratory is as follows:

<u>Avionics Laboratory</u> (Table B.13-A.1):

1. Technical Merit
2. Air Force Need
3. Resource Availability
   Educating Personnel
4. Timeliness of Completion
5. Keep Contractor Honest
6. Cost/Benefit Ratio
7. Likelihood of Success

<u>Aero Propulsion Laboratory</u> (Table B.13-A.2):

1. Technical Merit
2. Air Force Need
3. Cost/Benefit Ratio
4. Likelihood of Success
5. Timeliness of Completion
6. Educating Personnel
7. Keep Contractor Honest
8. Other
9. Resource Availability

Flight Dynamics Laboratory (Table B.13-A.3):

1. Air Force Need
2. Cost/Benefit Ratio
   Technical Merit
3. Resource Availability
4. Likelihood of Success
5. Timeliness of Completion
   Educating Personnel
6. Keep Contractor Honest
7. Educating Personnel
8. Cost/Benefit Ratio
9. Other (unlisted) Factors

Materials Laboratory (Table B.13-A.4):

1. Air Force Need
2. Technical Merit
3. Resource Availability
   Likelihood of Success
4. Timeliness of Completion
5. Cost/Benefit Ratio
6. Educating Personnel
   Keep Contractor Honest

The ranking of factors by management level is as follows:

Researcher (Table B.13-B.1):

1. Air Force Need
2. Technical Merit
3. Resource Availability
4. Likelihood of Success
5. Keep Contractor Honest
6. Timeliness of Completion
7. Educating Personnel
8. Cost/Benefit Ratio
9. Other

Supervisor (Table B.13-B.2):

1. Air Force Need
2. Technical Merit
3. Resource Availability
   Educating Personnel
4. Timeliness of Completion
5. Likelihood of Success
6. Keep Contractor Honest

Branch Chief (Table B.13-B.3):

1. Technical Merit
   Air Force Need
2. Resource Availability
3. Cost/Benefit Ratio
   Keep Contractor Honest
4. Likelihood of Success
5. Timeliness of Completion
   Educating Personnel

Directorate Head (Table B.13-B.4):

1. Air Force Need
2. Cost/Benefit Ratio
3. Technical Merit
4. Resource Availability
5. Likelihood of Success
6. Timeliness of Completion

Formal Decision Method Used

Of the forty managers surveyed, only twelve (30%) indicated they used a formal decision-making method (Table B.14). In a breakdown by laboratory of those managers who responded positively, four came from the Avionics lab, three each came from the Flight Dynamics and Materials labs, and two came from the Aero Propulsion lab (Table B.14-A).

In a breakdown by management level, the branch chiefs had the greatest percentage of positive use with 50 percent (four of eight), followed by a 33.3 percent (five of fifteen) response for the supervisors. Of the sixteen researchers interviewed, only three (19%) used a formal decision method and the one directorate head interviewed did not use a formal method (Table B.14-B).

In a breakdown by experience, there did not appear to be any discernible patterns. Many of the more senior people did say, however, that they tended to trust their own instincts in selecting projects rather than use a formal decision technique.

Formal Decision-Making Techniques

The techniques that were listed and their frequencies of response are as follows: checklist and profile chart, scoring models, decision trees and goal programming were each used by five of the respondents. Cost/benefits ratios were used by four of the participants, two individuals used multiple objective methods and one respondent used dynamic programming (Table B.15-A). Surprisingly enough, no one used linear programming.

Those respondents who indicated they used a formal decision method were much more likely to use one of the techniques listed than those in the sample who did not use any formal decision method (Table B.15-B). There did not, however, appear to be much of a difference between those with an operations research/management science background and those with no such background (Table B.15-C). On the contrary, it appears form the data sample that those with no such background were slightly more likely to use one of the listed techniques.

Decision-Making Technique Awareness

The decision-making techniques the respondents were aware of are listed from most aware to least aware as follows (Table B.17):

1. Cost/Benefit Ratio
   Decision Trees
2. Checklist and Profile Chart
   Linear Programming
3. Scoring Models
4. Goal Programming
5. Multiple Objective Programming
6. Dynamic Programming
7. Chance Constrained Programming
8. Other Techniques (not specified)

In a breakdown by laboratory (Table B.17-A) the Avionics and Flight Dynamics laboratories appeared to be more aware of the listed techniques than the Aero Propulsion and Materials laboratories. The respondents from the Aero Propulsion lab seemed to be slightly more aware of the techniques than the Materials lab.

An analysis of the managerial levels (Table B.17-B) reveals that supervisors appear to be the most aware of these techniques. The researchers and branch chiefs were about even on a percentage basis. Since there was only one directorate head interviewed, an analysis of that response data would be irrelevant.

Respondent's Desire to Change Methods

Of the forty respondents interviewed, only five indicated they were considering the possibility of changing their selection methods (Table B.18). Of these five, four were from the Avionics lab and one was from the Flight Dynamics lab (Table B.18-A). In a management breakdown, two of the five participants were researchers and three were supervisors (Table B.18-B).

Participant's Formal Laboratory Management Training

This area was divided into two segments. Those respondents who received their training via an AFIT Professional Continuing Education (PCE) course and those who received training through another lab course or workshop.

Twelve of the forty respondents reported taking a laboratory PCE course (Table B.7). Five respondents reported taking other types of lab management training courses (Table B.8). Well over half (57.5%) had no such formal laboratory management training.

Manager's Budget vs Formal Decision Methods

The formal decision methods did not necessarily have to be one of those listed in the survey. Twelve of the forty respondents indicated that they did change their methods in response to the size of their project budget. Of those who responded positively, the vast majority had budgets which exceeded \$1 million (Table B.10).

Project Selection/Assignment vs Formal Decision Methods

A point to be emphasized here is that project selection denotes in-house research project selection only, while project assignment may be in-house assignment or contract project assignment under a alboratory manager's control. No apparent relationship seemed to reveal itself with respect to project selection. Those individuals selecting two projects per year seemed to have the greatest propensity to use a formal decision method (Table B.11). For projects assigned (Table B.12), those individuals assigned ten or more projects seemed inclined towards using a formal decision method.

Selection Method vs Project Value

Twelve respondents (30%) indicated that their project selection methods varied according to the dollar value of their budgets (Table B.19). However, none of the participants gave exact dollar values where one method transitioned to another. They would simply define the transition in terms of going from a "small dollar" project to a "large dollar" project.

Project Portfolio Selection

Nineteen of the forty participants engaged in selection of portfolios of research projects (Table B.20). Portfolio project selection involves two or more individual research projects that are used to obtain a single broad research objective. Of the techniques listed, goal programming was the most popular choice, followed closely by multiple objective methods. Linear programming and dynamic programming were also indicated to be used for this purpose (Table B.20-A).

V. Conclusions and Recommendations

Introduction

The conclusions and recommendations in this chapter are based on the data analysis of the forty interviews that were conducted for this research. The chapter is broken down into the following sections: 1) research project selection factors, 2) formal decision method use, 3) formal decision-making techniques, 4) decision-making technique awareness, 5) selection improvement, 6) formal laboratory management training, 7) budget and decision method relationship, 8) project selections/assignments per year, 9) decision method relationships, relationships between project value and selection method use, 10) project portfolio selection, and 11) recommendations for further research.

Research Project Selection Factors

The top three factors considered to be the most important by most of the respondents were Air Force need, technical merit, and resource availability. Air Force R&D laboratory managers appear to match their commercial counterparts in meeting organizational goals (Air Force need), professional goals (technical merit), and matching these ambitions with a judicious management of available resources.

Formal Decision Method

The vast majority (70%) of the respondents surveyed did not use a formal decision-making method. Most managers surveyed said that projects were selected via a group consensus of researchers or by a management committee.

Many of the project selection decisions are made at the branch chief level. It then may be no accident that branch chiefs in the survey had the highest positive response percentage for using a formal decision-making method.

Formal Decision-Making Techniques

The four techniques with the greatest positive response were checklist and profile charts, scoring models, decision trees and goal programming. With the exception of goal programming, the first three methods are relatively simple to learn and easy to use. This may have been a factor in their popularity. The response to goal programming came as somewhat of a surprise in that it is one of the more complex decision-making techniques. Its flexibility in incorporating several objectives could be the reason several of the respondents use it.

The research also indicated that exposure to operations research methods did not appear to influence the use of such techniques for project selection. In some cases exposure produced the opposite effect. Participants felt the techniques were too complex, time consuming and generally unwieldy for project selection use at their level.

Decision-Making Technique Awareness

The techniques the respondents were aware of most were those methods most commonly used in commercial laboratories. It was also a point of interest that linear programming ranked ahead of goal programming in awareness; whereas it was ranked below it in actual use. An explanation for this may be that if one were to use an operations research method, goal programming would be more flexible than linear programming due to the ability to work with multiple goal objectives.

The significantly greater number of respondents who are aware of the listed techniques, contrasted with the relatively low response of techniques usage, illustrates two points. First, since project selection in most of AFWAL is by a group consensus of managers, use of these methods may be irrelevant. Second, the techniques themselves may be so time consuming and complex (particularly in the case of the operating research methods), that they are simply impractical to use. These two findings are the most profound of this project. They tend to indicate that most of the decision-making tools are impractical because of disharmony with the existing laboratory management style and the technical weaknesses of the methods.

Respondent's Desire to Change Methods

Most of the respondents felt their selection methods worked well and this was reflected in their answers to this question. Those that responded positively to this question did not specify switching to a particular method or technique. The respondents merely indicated that their selection process may become more/less formal than it was at present.

An explanation for the low positive response to this question may be the feeling expressed by some supervisors and researchers that they have little control over final project selection. Final decisions on project selection are often reserved for the branch chief level or higher. Branch chiefs felt that their project selection decisions were sound ones and thus had little reason to change.

Formal Laboratory Management Training

Over half of the participants in this study did not take a PCE course or any other type of formal laboratory management training course. Of those who did, few could recall if project selection was an area covered by these courses. It then appears that attendance at either a PCE or other similar lab management courses had little impact on a manager's selection method.

Manager's Budget vs Formal Decision Methods

About one-quarter of the respondents indicated that a relationship existed between these two factors. Of this group, the feeling was that the larger the budget they controlled the greater was their propensity to use some sort of formal decision-making process.

There is an obvious reason to explain this trend. Higher budgets are often controlled by managers in upper levels of the organization. These individuals often have to justify their budgets to still higher management levels. Formal decision-making methods are an accepted tool for such a team.

Project Selection/Assignment vs Formal Decision Method Use

No relationship appeared between the number of projects selected per year and the inclination to use a formal decision method. However, there did seem to be a relationship between the volume of projects assigned per year and the use of some sort of formalized method. This tendency seemed to manifest itself in those managers who were assigned the responsibility of ten or more projects. The reason for the level of frequency response in this category may be that upper levels of management fell into this bracket most often and are under greater scrutiny than are managers in lower levels of their respective laboratory organizations.

Selection Method vs Project Value

The response to this question was small (30%). The respondents how did vary their selection methods based on a project's dollar value typically stated they went from a less formal method to a method that involved a greater management or group consensus. They also could not name specific transition points where these changes occurred. The only conclusion drawn from this sample is that a perception exists that a more expensive project requires a greater management involvement at the time of selection.

Project Portfolio Selection

While a substantial number of participants engaged in portfolio selection, most who did treated the process no differently than single project selection. Correspondingly, the techniques used for this activity were similar to those used for selecting a single research project. Project portfolio selection is not viewed as a task uniquely different from ordinary single project selection at AFWAL.

Recommendation for Further Research

This exploratory research was conducted to examine how research project selection is conducted at AFWAL. Further research should be conducted to explore some of the aspects of the research project selection process in the Air Force laboratories that have surfaced here.

Some of those areas are: the use of group consensus, the impact of management information systems, and the impact a decision support system may have on research project selection in AFWAL or any other Air Force laboratory. In addition, this study could be repeated using a survey to obtain a broader and deeper sample from each of the four laboratories, thus permitting the formulation of more conclusive observations.

Appendix A: Interview Questions

NAME (optional) ______________________________

1. LABORATORY ______________________________

2. [] MILITARY [] CIVIL SERVICE

3. RANK/GRADE ________________

4. YEARS EXPERIENCE ______

5. EDUCATIONAL LEVEL:

   [] No College
   [] AA
   [] Bachelor's
   [] Master's
   [] Doctorate

6. MANAGEMENT LEVEL: ______________________________

7. MAJOR FIELD OF STUDY:

   AA ______________________
   Bachelors ______________________
   Master's ______________________
   Doctorate ______________________

8. Did you ever take an operations research or management science course? [] Yes [] No

9. Did you ever take a Professional Continuing Education (PCE) course in laboratory management? [] Yes [] No

   If Yes: Name of Course: ____________________

   Date Taken: ____________________

   Did this course cover project selection? [] Yes [] No

10. Have you ever taken any other type of lab course that dealt with the subject of project selection (i.e., a local lab course or workshop)? [] Yes [] No

11. Size of budget you're responsible for: $__________

12. How many projects do you select per year? __________

13. How many projects are assigned to you? ________

14. What factors do you consider important when selecting a research project? (Rank by Priority 1-9):

_____	Cost/Benefit Ratio	_____	Likelihood of Success
_____	Technical Merit	_____	Timeliness of Completion
_____	Resource Availability	_____	Air Force Need
_____	Education	_____	Other
_____	Keep Contractor Honest		

15. Do you use a formal decision-making method for proposal selection?

[] Yes [] No

16. If Yes: What methods do you use? (Rank by Frequency of Use 1-10):

_____ Checklist and Profile Charts
_____ Scoring Models
_____ Cost/Benefit Ratios
_____ Decision Trees
_____ Linear Programming
_____ Goal Programming
_____ Dynamic Programming
_____ Chance Constrained Programming
_____ Multiple Objective Programming
_____ Other

____
____
____

17. What are the dollar values of these projects?

[] Less than \$100K [] \$300K - \$1M
[] \$100K - \$300K [] Greater than \$1M

18. What project selection methods are you aware of?

_____ Checklist and Profile Charts
_____ Scoring Models
_____ Cost/Benefit Ratios
_____ Decision Trees
_____ Linear Programming
_____ Goal Programming
_____ Dynamic Programming
_____ Chance Constrained Programming
_____ Multiple Objective Programming
_____ Other

____
____
____

19. Do you anticipate changing your selection methods in the near future?

[] Yes [] No

If Yes, please describe those changes.

20. Does the selection method vary according to the dollar value of the project?

[] Yes [] No

If Yes, what method would you choose for the following project dollar values?

Less than $100K ______________________
$100K - $300K ______________________
$300K - $1M ______________________
Greater than $1M ______________________

21. Do you select portfolios of research projects?

[] Yes [] No

If Yes, what methods do you use?

- [] Linear Programming
- [] Goal Programming
- [] Multiple Objective Programming
- [] Dynamic Programming
- [] Chance Constrained Programming
- [] Other (List):

____
____
____

22. Additional Comments:

Appendix B: Summarized Responses to Interview Questions

TABLE B.1

Rank/Grade

Rank/Grade	Responses
1st Lieutenants	2
Majors	1
Lieutenant Colonels	1
TOTAL MILITARY	4
GS-9	1
GS-11	1
GS-12	8
GS-13	7
GS-14	8
GM-15	10
TOTAL CIVIL SERVICE	35
1 Unknown	-

TABLE B.2

Years of Laboratory Experience

Years Experience	Number of Responses
Less than 2	3
2 - 4	4
5 - 10	7
11 - 20	13
21 - 30	11
More than 30	2
TOTAL RESPONSES	40

TABLE B.3

Educational Level

Level Achieved	Frequency of Response
No College	1
AA	0
Bachelor's Degree	12
Master's Degree	14
Doctorate Degree	13
TOTAL	40

TABLE B.4

Management Level

Management Level	Frequency of Response
Researcher	16
Supervisor	15
Branch Chief	8
Directorate Head	1
TOTAL	40

TABLE B.5

Major Field of Study

Academic Discipline	Frequency of Response
Engineering	26
Science	13
Mathematics	1
Non-Technical	0
TOTAL	40

TABLE B.6

Operations Research/Management Science Background

Response	Frequency
Yes	14
No	26

TABLE B.7

Respondents with PCE Background

Response	Frequency
Yes	12
No	28

TABLE B.8

Respondents Who Have Taken Other Lab Management Courses

Response	Frequency
Yes	5
No	35

TABLE B.9

Budget Size and Formal Decision Method (FDM) Use

Budget Size	Frequency of Response
Less than 100K	3
100K - 300K	4
300K - 1M	6
More than 1M	27
TOTAL	40

TABLE B.10

Budget Size vs FDM Use

Budget Size	Use FDM	Do Not Use FDM
Less than 100K	0	3
100K - 300K	2	2
300K - 1M	0	6
More than 1M	10	17
TOTAL	12	28

TABLE B.11

Relationship Between Number of Projects Selected Per Year and Use of an FDM

Use of FDM	Projects Selected Per Year 1	2	3	4	5	6	7	8	9	10
Yes	10	5	4	1	3	0	1	0	0	4
No	1	4	2	0	2	1	0	0	0	2
TOTAL	11	9	6	1	5	1	1	0	0	6

TABLE B.12

Relationship Between Number of Projects Assigned Per Year and Use of an FDM

FDM	Projects Selected Per Year 1	2	3	4	5	6	7	8	9	10
Yes	3	0	7	5	4	2	0	0	1	6
No	0	0	1	2	0	0	0	0	0	9
TOTAL	3	0	8	7	4	2	0	0	1	15

TABLE B.13

Selection Factors and Their Ranking of Importance

<u>Acronym</u>:

CBR	Cost Benefit Ratio
TM	Technical Merit
RA	Resource Availability
LOS	Likelihood of Success
TOC	Timeliness of Completion
EDPERS	Educate Personnel (Lab Project Personnel
KCH	Keep Contractor Honest
AFN	Air Force Need
OTH	Other

<u>Interpretation of Scale</u>:

1. Most Important
9. Least Important
0. Not Considered

Table B.13-A

	Overall Frequency of Response									
	1	2	3	4	5	6	7	8	9	10
CBR	5	5	8	6	3	3	3	1	0	6
TM	15	17	5	1	0	0	0	0	0	2
RA	3	8	13	8	2	2	0	0	0	4
LOS	0	5	4	11	6	2	3	4	0	5
TOC	0	1	3	6	7	9	3	2	0	9
EDPERS	1	4	6	3	6	3	6	2	0	9
KCH	0	2	3	2	4	5	5	8	0	11
AFN	22	8	2	2	1	1	0	1	0	3
OTH	0	0	0	0	0	0	0	0	2	38

Table B.13-A.1

	Laboratory Frequency of Responses - Avionics									
	1	2	3	4	5	6	7	8	9	10
CBR	1	0	1	2	0	1	2	0	0	3
TM	1	4	0	0	0	0	0	0	0	1
RA	5	2	3	2	1	1	0	0	0	0
LOS	1	2	1	11	1	0	1	2	0	2
TOC	0	0	1	4	1	0	1	1	0	2
EDPERS	0	2	3	1	2	0	0	0	0	2
KCH	0	1	1	0	1	3	1	1	0	12
AFN	4	1	1	0	0	1	0	0	0	3
OTH	0	0	0	0	0	0	0	0	0	10

Table B.13-A.2

	Laboratory Frequency of Responses-Aero Propulsion									
	1	2	3	4	5	6	7	8	9	10
CBR	1	1	5	0	1	0	0	1	0	1
TM	5	3	1	1	0	0	0	0	0	0
RA	2	1	3	1	0	1	0	0	0	2
LOS	0	1	0	3	2	0	2	0	0	2
TOC	0	0	1	1	1	3	0	1	0	3
EDPERS	0	0	0	1	1	2	3	0	0	3
KCH	0	0	0	0	1	1	2	3	0	3
AFN	3	4	0	1	1	0	0	1	0	0
OTH	0	0	0	0	0	0	0	0	2	8

Table B.13-A.3

	Laboratory Frequency of Responses-Flight Dynamics									
	1	2	3	4	5	6	7	8	9	10
CBR	2	4	1	2	1	0	0	0	0	0
TM	3	4	3	0	0	0	0	0	0	0
RA	0	1	4	4	1	0	0	0	0	0
LOS	0	1	0	3	2	1	0	2	0	1
TOC	0	0	1	1	2	3	1	0	0	2
EDPERS	0	2	1	0	2	1	2	0	0	2
KCH	0	0	1	1	1	1	1	2	0	3
AFN	8	2	0	0	0	0	0	0	0	0
OTH	0	0	0	0	0	0	0	0	0	10

Table B.13-A.4

	Laboratory Frequency of Responses - Materials									
	1	2	3	4	5	6	7	8	9	10
CBR	2	4	1	2	1	0	0	0	0	0
TM	3	4	3	0	0	0	0	0	0	0
RA	0	1	4	4	1	0	0	0	0	0
LOS	0	1	0	3	2	1	0	2	0	1
TOC	0	0	1	1	2	3	1	0	0	2
EDPERS	0	2	1	0	2	1	2	0	0	2
KCH	0	0	0	1	1	1	1	2	0	3
AFN	8	2	0	0	0	0	0	0	0	0
OTH	0	0	0	0	0	0	0	0	0	10

Table B.13-B.1

	Management Frequency of Responses - Researchers									
	1	2	3	4	5	6	7	8	9	10
CBR	4	2	4	2	1	1	0	1	0	1
TM	6	7	1	1	0	0	0	0	0	1
RA	2	2	6	2	1	1	0	0	0	2
LOS	0	2	0	4	3	0	3	1	0	1
TOC	0	0	2	2	1	3	2	2	0	4
EDPERS	0	1	2	1	2	2	3	1	0	4
KCH	0	0	1	1	3	3	1	3	0	4
AFN	7	5	0	1	1	0	0	1	0	1
OTH	0	0	0	0	0	0	0	0	2	14

Table B.13-B.2

	Management Frequency of Responses - Supervisors									
	1	2	3	4	5	6	7	8	9	10
CBR	1	2	3	4	0	1	1	0	0	3
TM	5	7	2	0	0	0	0	0	0	1
RA	1	3	4	3	1	1	0	0	0	2
LOS	0	2	3	3	2	1	0	3	0	1
TOC	0	1	1	1	4	3	1	0	0	4
EDPERS	0	1	4	2	2	1	1	0	0	4
KCH	0	2	1	1	1	0	3	2	0	5
AFN	10	3	0	0	0	1	0	0	0	1
OTH	1	0	0	0	0	0	0	0	0	0

Table B.13-B.3

	Management Frequency of Responses - Branch Chiefs									
	1	2	3	4	5	6	7	8	9	10
CBR	0	0	1	0	2	1	2	0	0	2
TM	4	3	1	0	0	0	0	0	0	0
RA	0	3	3	2	0	0	0	0	0	0
LOS	0	1	1	4	0	1	0	0	0	1
TOC	0	0	0	3	2	2	0	0	0	1
EDPERS	1	2	0	0	2	0	2	1	0	0
KCH	0	0	1	0	0	2	1	3	0	1
AFN	4	0	2	1	0	0	0	0	0	1
OTH	0	0	0	0	0	0	0	0	0	8

Table B.13-B.4

	Management Frequency of Responses - Director Head									
	1	2	3	4	5	6	7	8	9	10
CBR	0	1	0	0	0	0	0	0	0	0
TM	0	0	1	0	0	0	0	0	0	0
RA	0	0	0	1	0	0	0	0	0	0
LOS	0	0	0	0	1	0	0	0	0	0
TOC	0	0	0	0	0	1	0	0	0	0
EDPERS	0	0	0	0	0	0	0	0	0	1
KCH	0	0	0	0	0	0	0	0	0	1
AFN	1	0	0	0	0	0	0	0	0	0
OTH	0	0	0	0	0	0	0	0	0	1

TABLE B.14

Formal Decision-Making Method Use

Overall Response	
Yes	12
No	28

Table B.14-A

	Laboratory Response	
	Yes	No
Avionics	6	4
Aero Propulsion	8	2
Flight Dynamics	7	3
Materials	7	3

Table B.14-B

	Management Response	
	Yes	No
Avionics	13	3
Aero Propulsion	10	5
Flight Dynamics	4	4
Materials	1	0

Table B.15

Frequencies of Methods Used (Ranking not performed)

Acronyms:

CPC	Checklist and Profile Charts
SM	Scoring Models
CBR	Cost/Benefit Ratio
DT	Decision Trees
LP	Linear Programming
GP	Goal Programming
DP	Dynamic Programming
CCP	Chance Constrained Programming
MOM	Multiple Objective Method
OTH	Other

Table B.15-A

Technique	Frequency of Response
CPC	5
SM	5
CBR	4
DT	5
LP	0
GP	5
DP	1
CCP	0
MOM	2
OTH	11

Table B.15-B

FDM Use	FDM vs Techniques Used CPC	SM	CBR	DT	LP	GP	DP	CCP	MOM	OTH
Yes	4	4	4	5	0	5	1	0	2	8
No	1	1	0	0	0	0	0	0	0	3

Table B.15-C

FDM Use	Management Science Background vs Techniques Used CPC	SM	CBR	DT	LP	GP	DP	CCP	MOM	OTH
Yes	1	1	2	2	0	2	1	0	1	3
No	4	4	2	3	0	3	0	0	1	8

TABLE B.16

Dollar Values of the Research Projects

Project Value	Frequency of Response
Less than 100K	10
100K - 300K	14
300K - 1M	10
More than 1M	6

TABLE B.17

Selection Techniques Participants Were Aware Of

Technique	Frequency of Awareness
CPC	18
SM	17
CBR	28
DT	28
LP	18
GP	14
DP	6
CCP	5
MOM	10
OTH	3

Table B.17-A

	Laboratory Response									
	CPC	SM	CBR	DT	LP	GP	DP	CCP	MOM	OTH
Avionics	5	5	8	8	7	6	2	2	6	0
Aero Prop.	6	4	6	5	4	2	0	1	1	1
Flt. Dynamics	5	6	8	9	4	3	3	2	1	1
Materials	2	2	6	6	3	3	1	0	2	1

Table B.17-B

	Management Response									
	CPC	SM	CBR	DT	LP	GP	DP	CCP	MOM	OTH
Researchers	6	6	10	9	5	2	0	2	2	1
Supervisor	8	7	11	12	9	8	4	2	5	1
Branch Chief	3	3	6	6	4	4	1	1	3	1
Directorate Hd.	1	1	1	1	0	0	1	0	0	0

TABLE B.18

Respondent's Desire to Change Selection Methods

Overall Response	
Yes	5
No	35

Table B.18-A

Laboratory	Response
Avionics	4
Aero Propulsion	0
Flight Dynamics	1
Materials	0

Table B.18-B

Management	Response
Researcher	2
Supervisors	3
Branch Chiefs	0
Directorate Head	0

TABLE B.19

Selection Method Varies by Project Dollar Value

Overall Response	
Yes	12
No	28

Table B.19-A

Laboratory	Positive Response
Avionics	5
Aero Propulsion	1
Flight Dynamics	5
Materials	1

Table B.19-B

Management Level	Positive Response
Researcher	4
Supervisor	5
Branch Chief	2
Directorate Head	1

TABLE B.20

Selection of Research Project Portfolios

Number of Respondents Who Select Portfolios	
Yes	19
No	21

Table B.20-A

Technique	Response
Linear Programming	1
Goal Programming	5
Multiple Objective	4
Chance Constrained Prog	0
Other	11

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This ~~investigation~~ thesis sought to determine how in-house research projects are selected at the U.S. Air Force Wright Aeronautical Laboratories (AFWAL). The problem was explored by studying ten aspects of the research project selection process.

This analysis was accomplished by using a combination of personal and telephone interviews. Ten individuals from each of the four AFWAL Laboratories were interrviewed. The results illustrated that few of the respondents used a formal decision method model when selecting research projects. Most of the in-house projects selected at AFWAL are chosen via a consensus of agreement between the various levels of management in each laboratory.

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